

Anticipating climate-change induced biome shifts for military installations

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US Army Corps of Engineers
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Overall Challenge

- Military installation ecosystems support:
 - ▶ Military training and testing
 - ▶ Populations of important plant/animal species
 - ▶ Examples of relatively pristine habitat

- Potential consequence of ecosystem shifts:
 - ▶ Training/testing type, time, capacity
 - ▶ Loss/gain of habitat
 - ▶ Changes to installation natural resource management plans



Question

Ideal:

How and when will ecosystems shift in response to climate change?

Two parts:

- ✓ Where can I currently find ecosystem driver conditions that match forecasted driver conditions?

How and when will current ecosystems shift in response?



Ecosystem drivers

1. Precipitation during the locally hottest quarter
2. Precipitation during the locally coldest quarter
3. Precipitation during the locally driest quarter
4. Precipitation during the locally wettest quarter
5. Ratio of precipitation to potential evapotranspiration
6. Temperature during the coldest locally quarter
7. Temperature during the hottest locally quarter
8. Sum of monthly Temp avg where Temp avg ≥ 5 deg C
9. Integer number of consecutive months where Temp avg ≥ 5 deg C

CC-Based

Developed by
Chris Zganjar at
TNC using
WORLDCLIM
(<http://www.worldclim.org>)

10. Available water holding capacity of soil
11. Bulk density of soil
12. Carbon content of soil
13. Nitrogen content of soil
14. Compound topographic index (relative wetness)
15. Solar interception
16. Day/night diurnal temperature difference

Constant



Develop global maps of drivers

- Choose general circulation models (GCM)
 - ▶ Hadley and PCM (high and low)
- Choose climate scenarios
 - ▶ A1 (higher CO₂) and B1(lower CO₂)
 - Explained on next slide
- Choose time
 - ▶ Current, 2055, 2085 (based on 30-yr averages)
- Collect maps (for current and 8 futures)



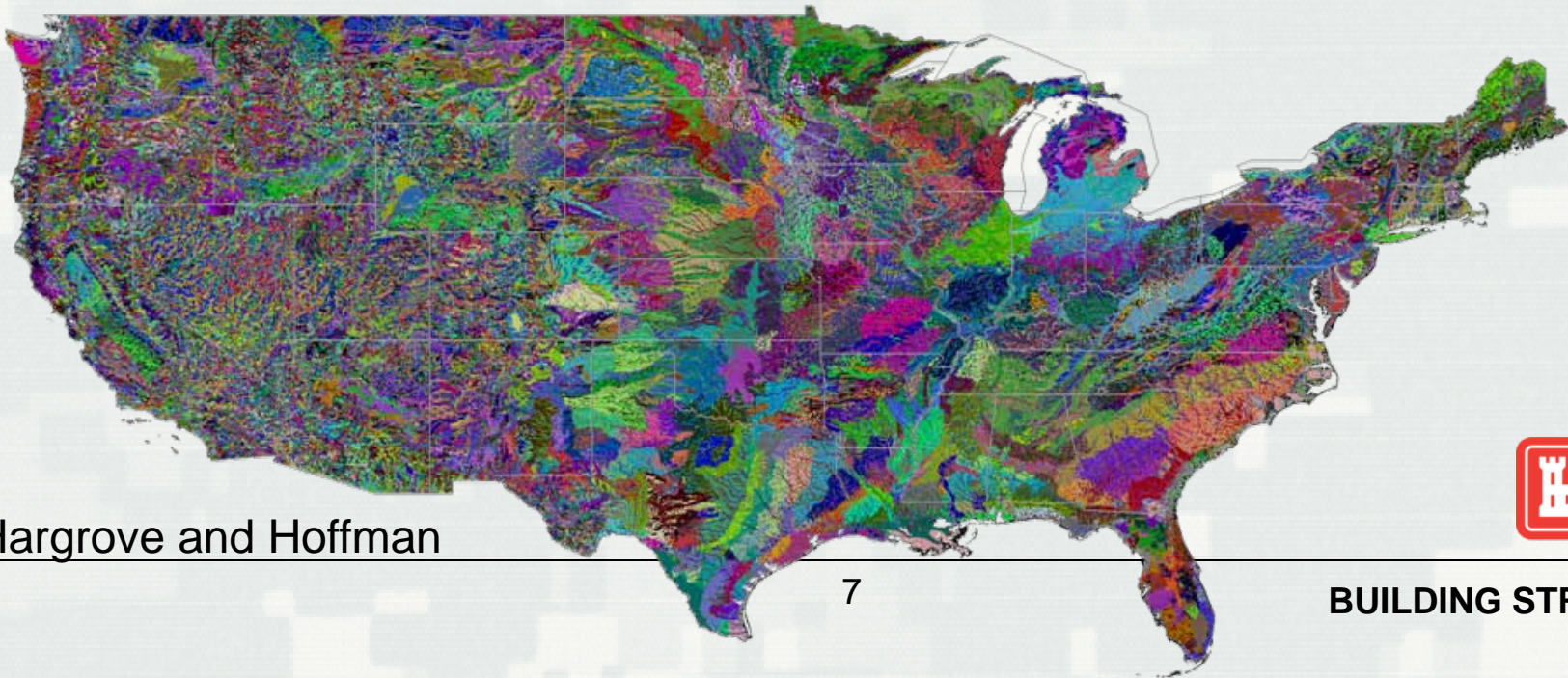
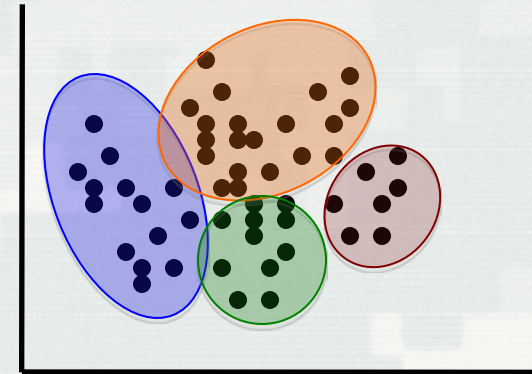
Scenarios

- A1 scenarios characterized by:
 - ▶ Rapid economic growth.
 - ▶ A global population that reaches 9 billion in 2050 and then gradually declines.
 - ▶ The quick spread of new and efficient technologies.
 - ▶ A convergent world.
- B1 scenarios are characterized by:
 - ▶ Rapid economic growth as in A1
 - ▶ Rapid changes towards a service and information economy.
 - ▶ Population as in A1.
 - ▶ Reductions in material intensity and the introduction of clean and resource efficient technologies.
 - ▶ An emphasis on global solutions to economic, social and environmental stability.



Cluster Analysis

- Convert all maps to a standard-deviation form
- Run cluster analysis (30,000 clusters) Simultaneously grouping all 9 sets across the

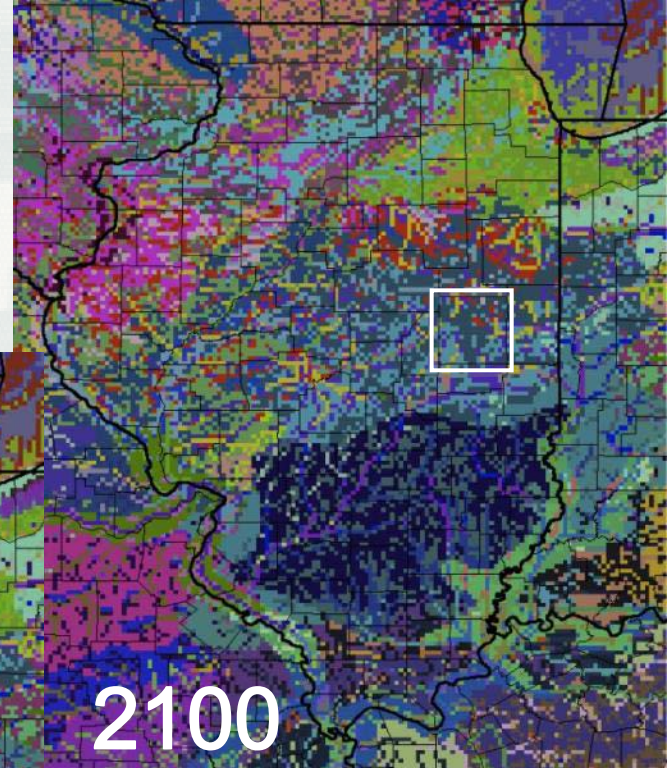
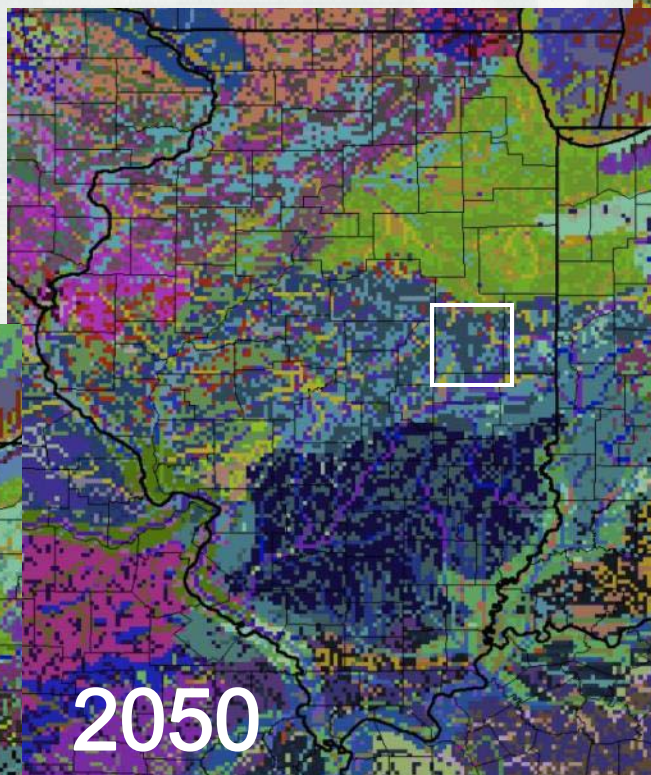
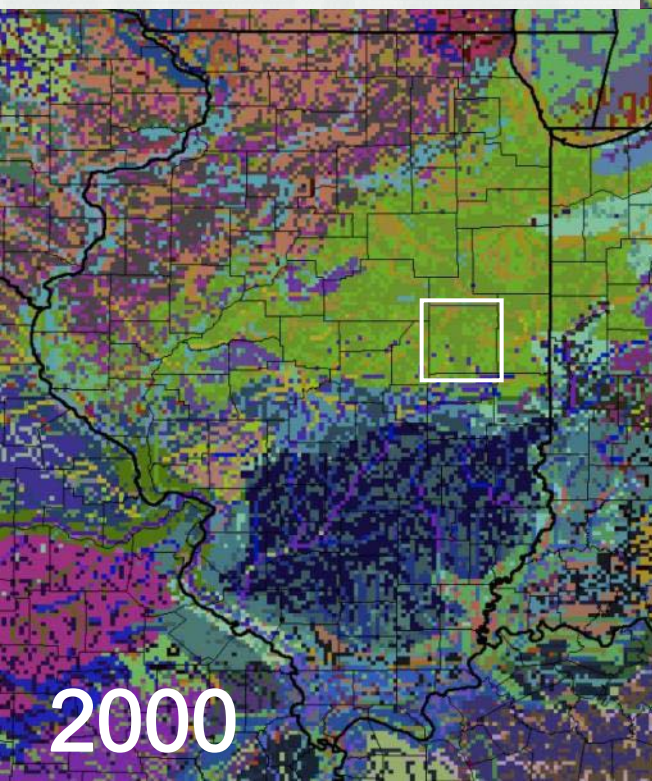


Hargrove and Hoffman



Illinois

Raw
Clusters

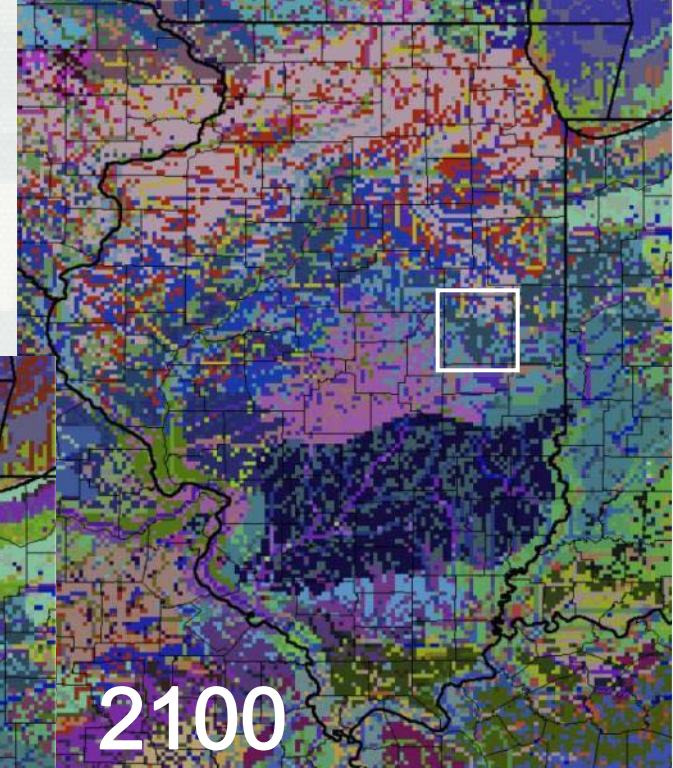
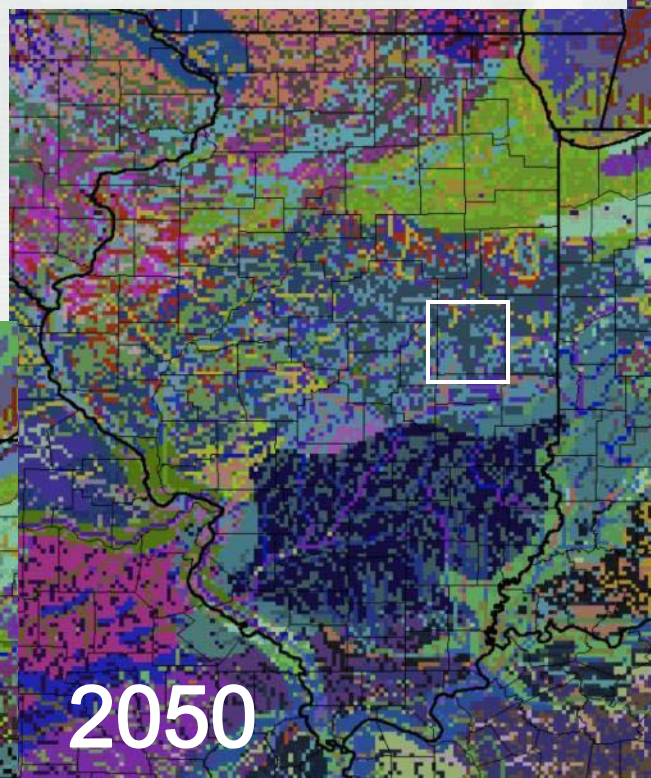
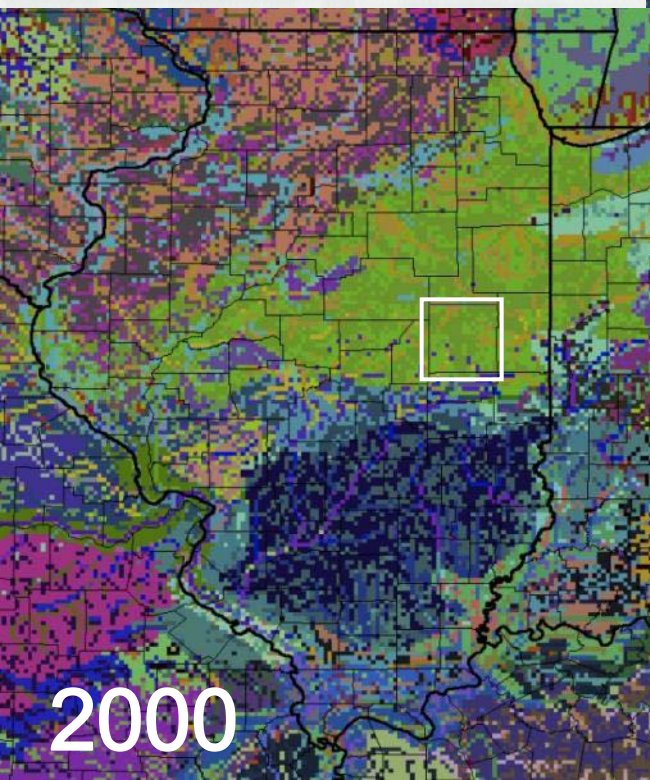


PCM
B1
Scenario



Illinois

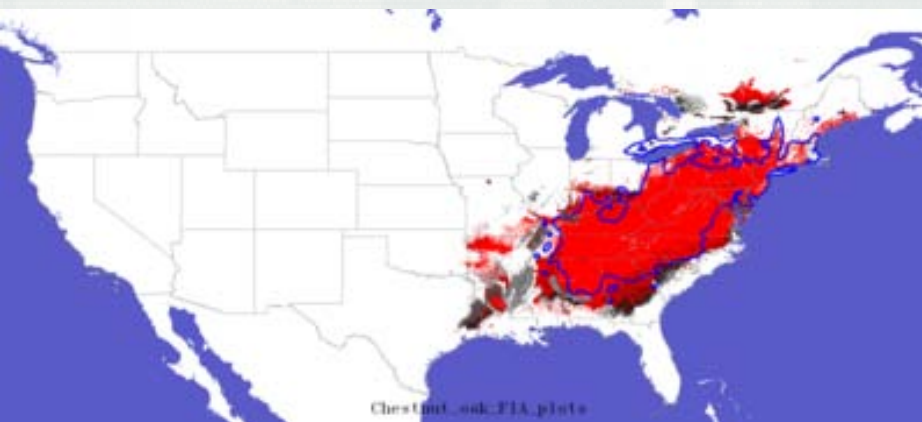
Raw
Clusters



Hadley
B1
Scenario



Forest Service Application



PCM, Scenario A1, 2000-2100 - Chestnut_oak



Hadley, Scenario A1, 2000-2050 - Longleaf_pine



http://www.geobabble.org/~hnw/global/treeranges2/climate_change



Results

- Correlation with GAP and TNC
- Application of correlation to future
- Sample look at Illinois
- Results for all military installations

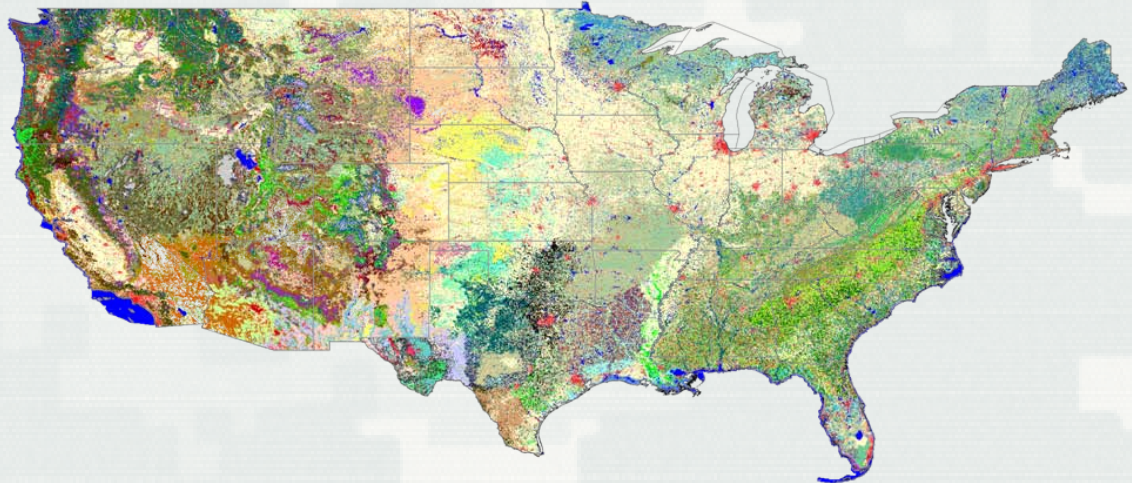


Correlate Clusters with Ecosystems

- Begin with ecosystem map

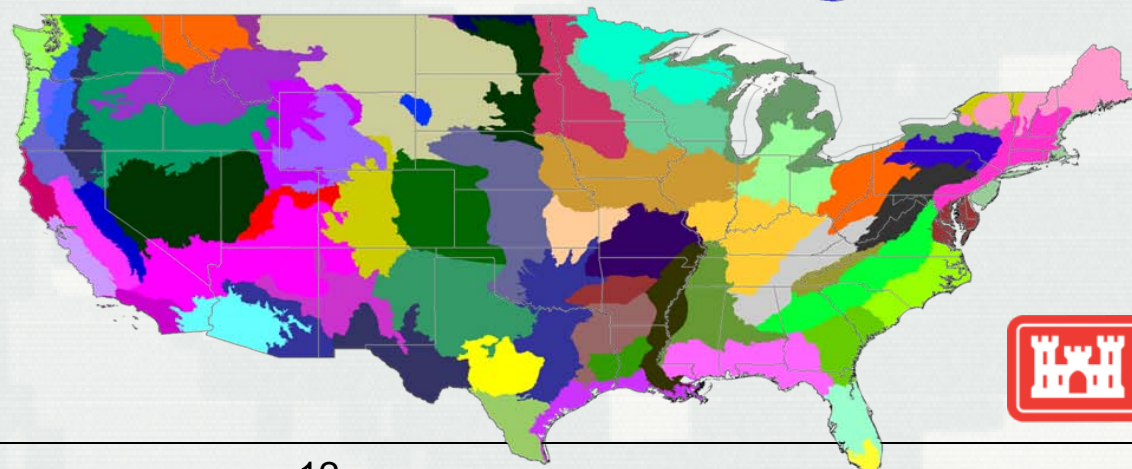
- ▶ GAP 2010

- US
 - 533 types



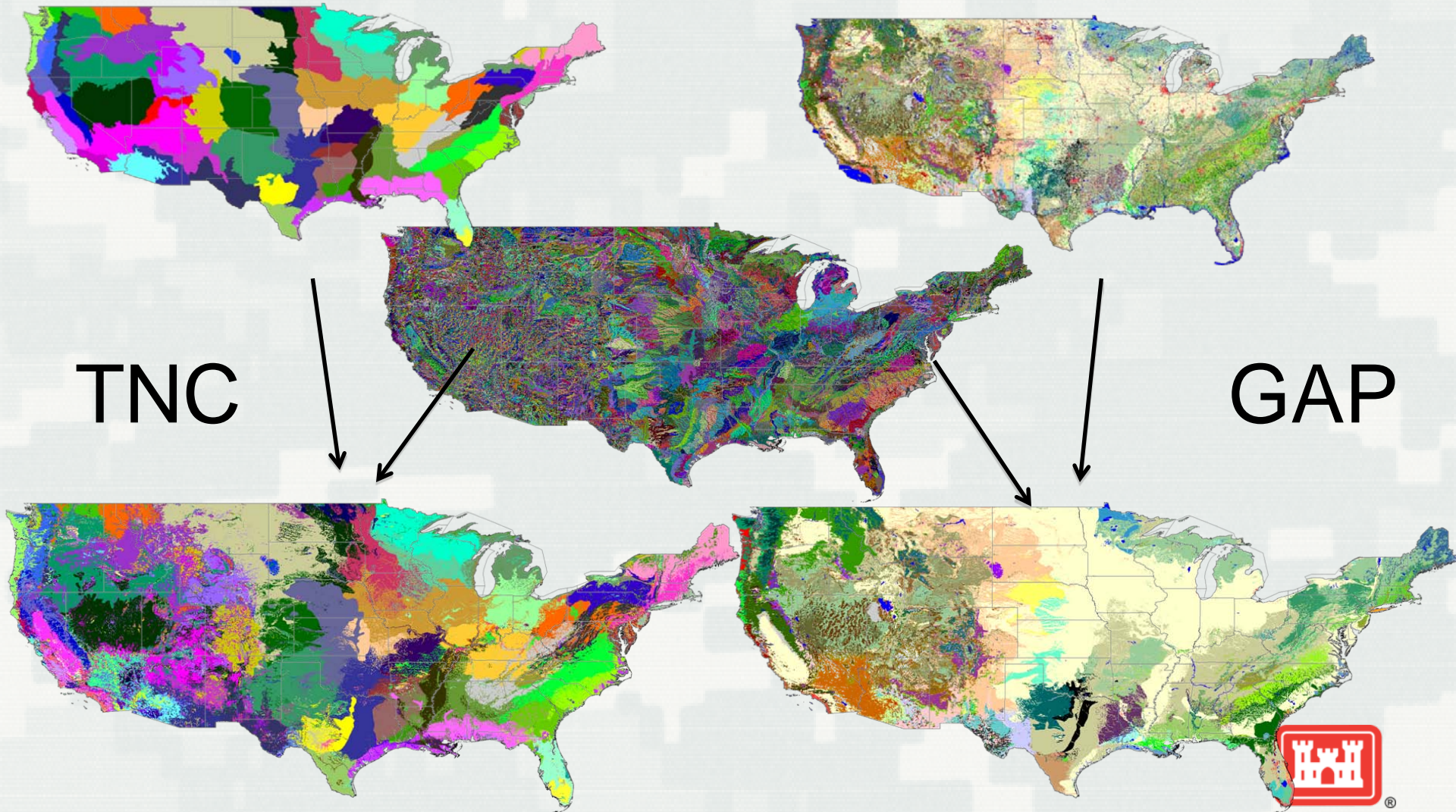
- ▶ TNC 2010

- Global
 - 814 types

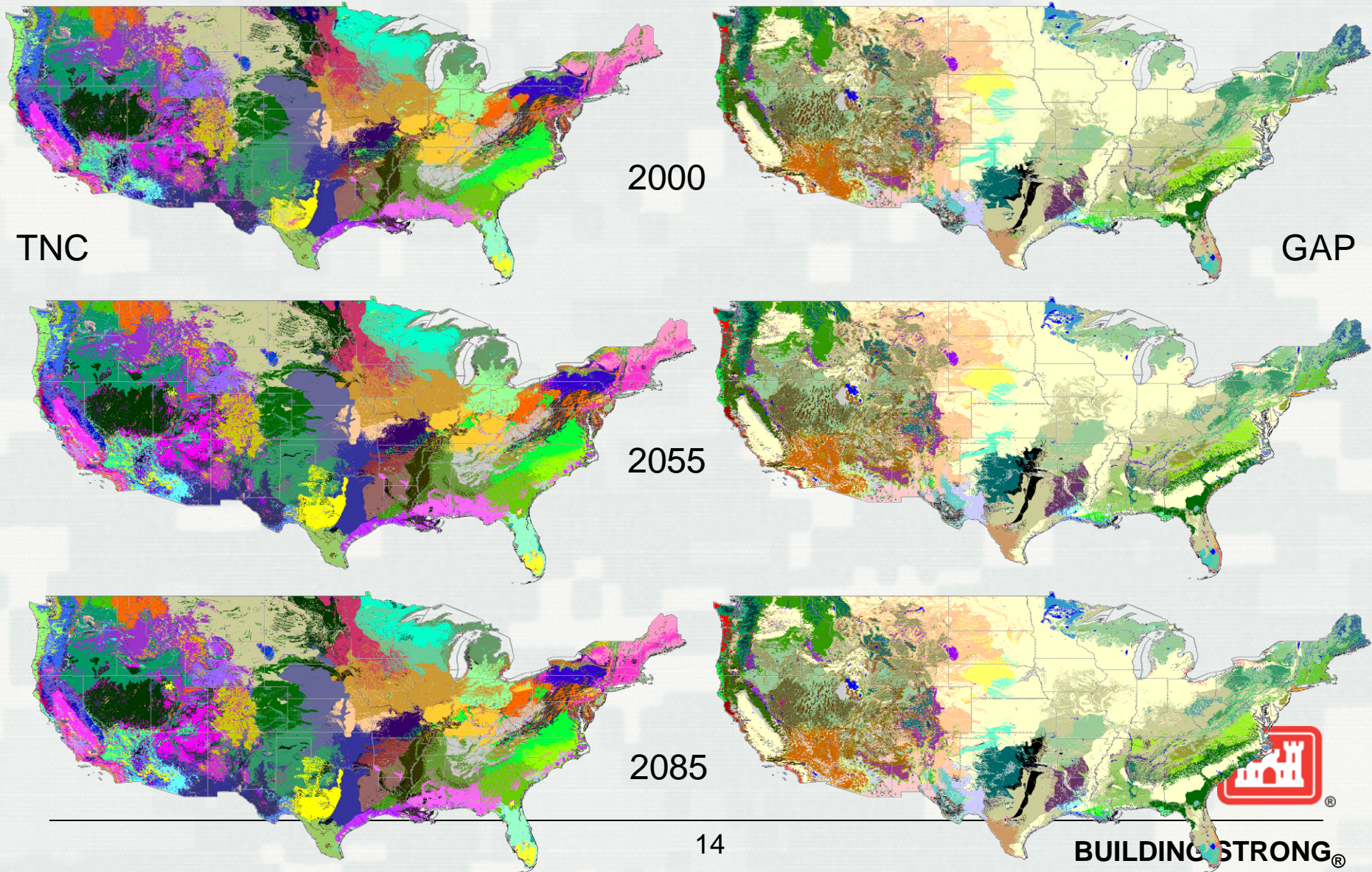


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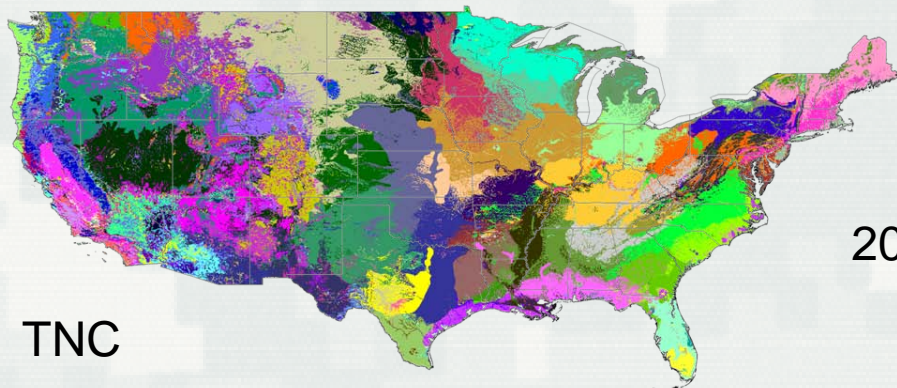
Correlate Clusters with Ecosystems



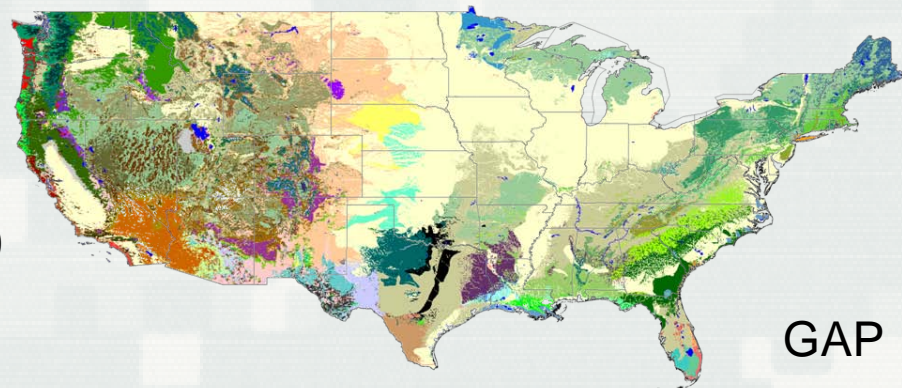
PCM model – B1 scenario (low-low)



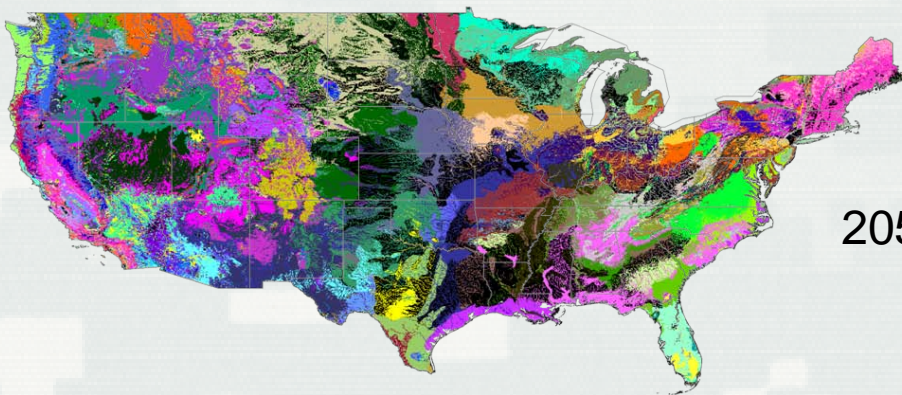
Hadley model – A1 scenario (high-high)



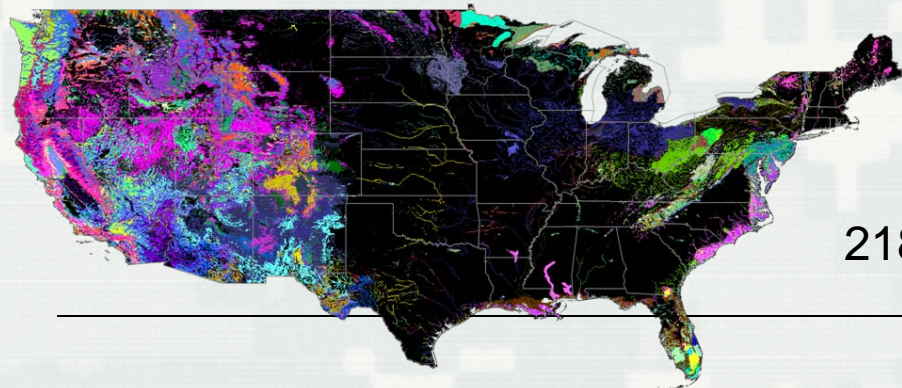
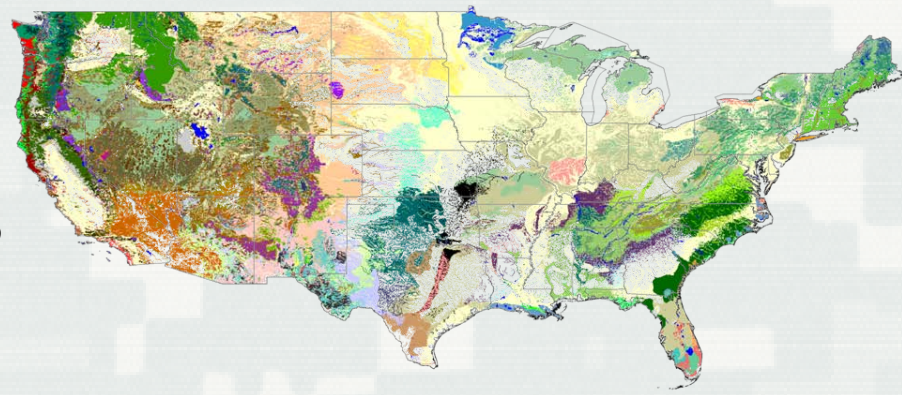
TNC



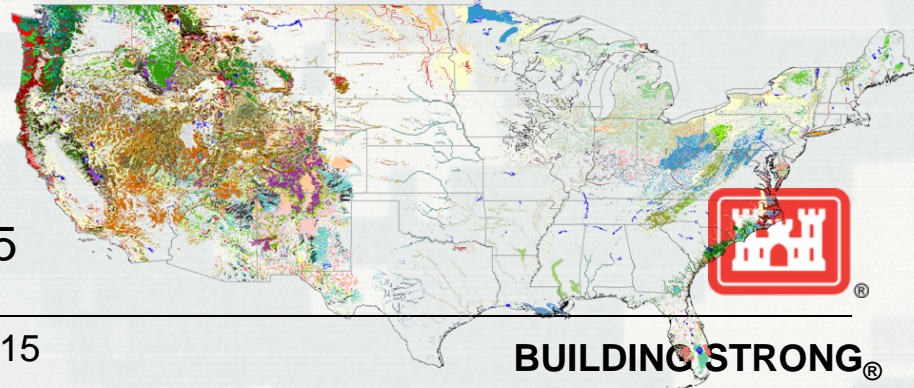
GAP



2055

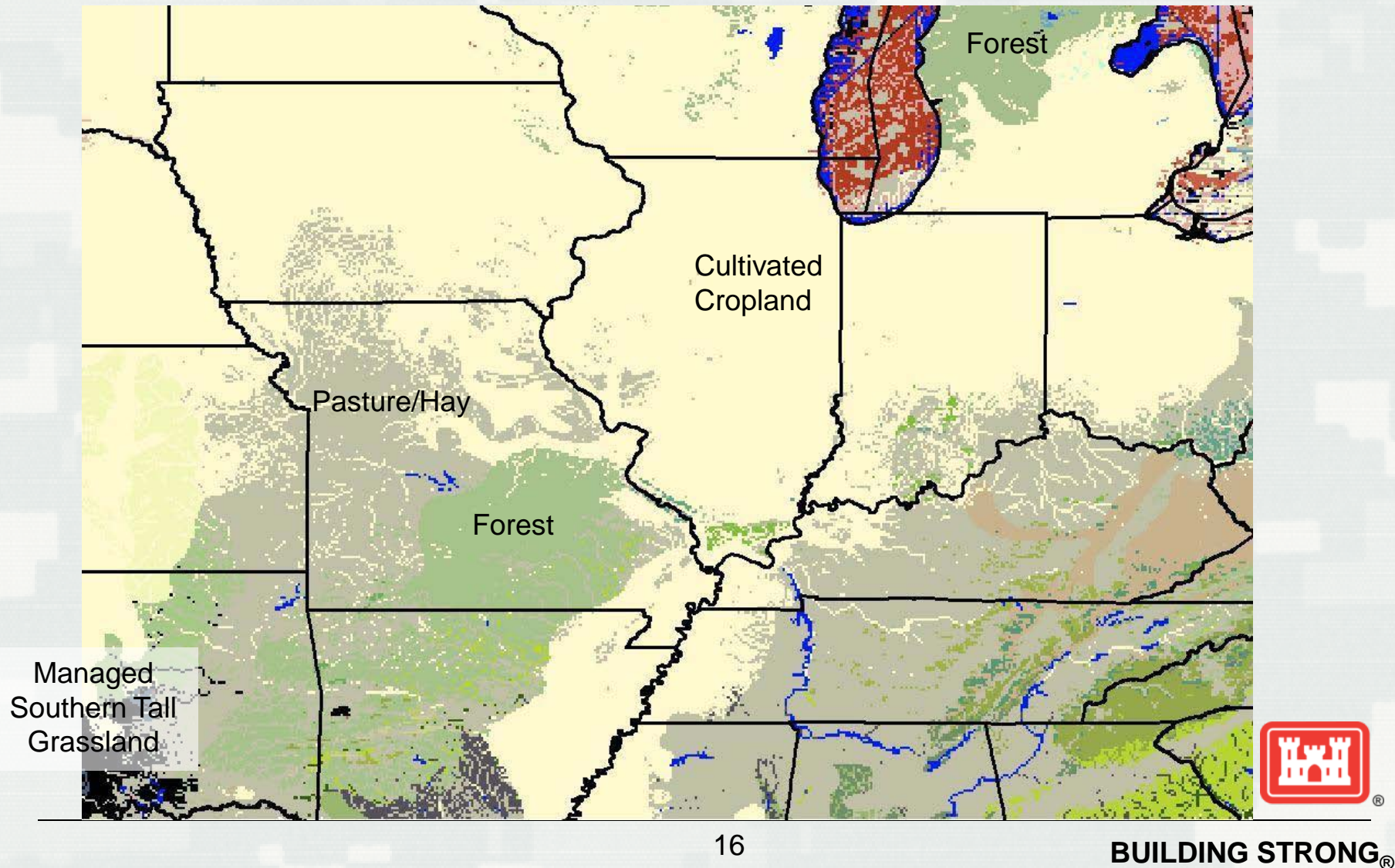


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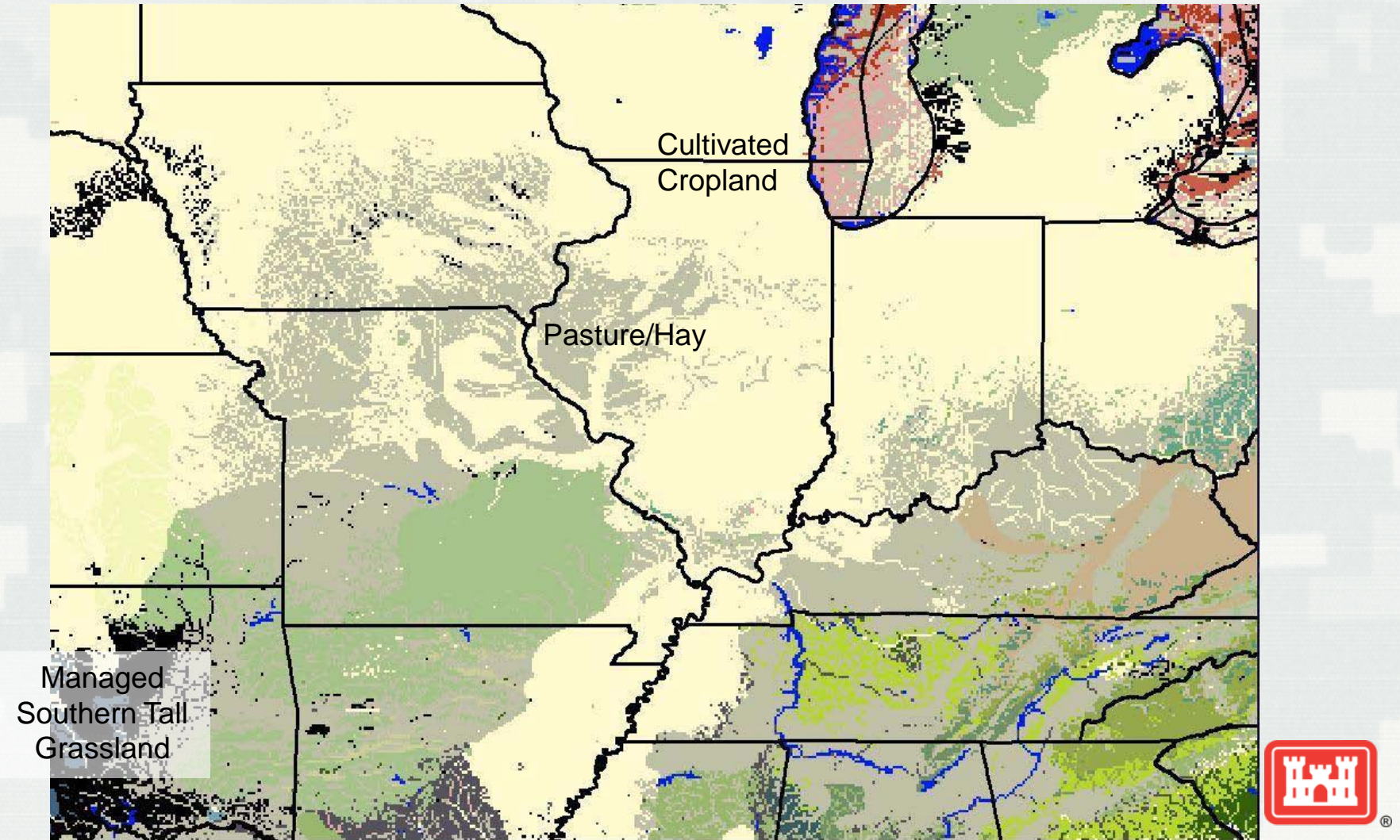


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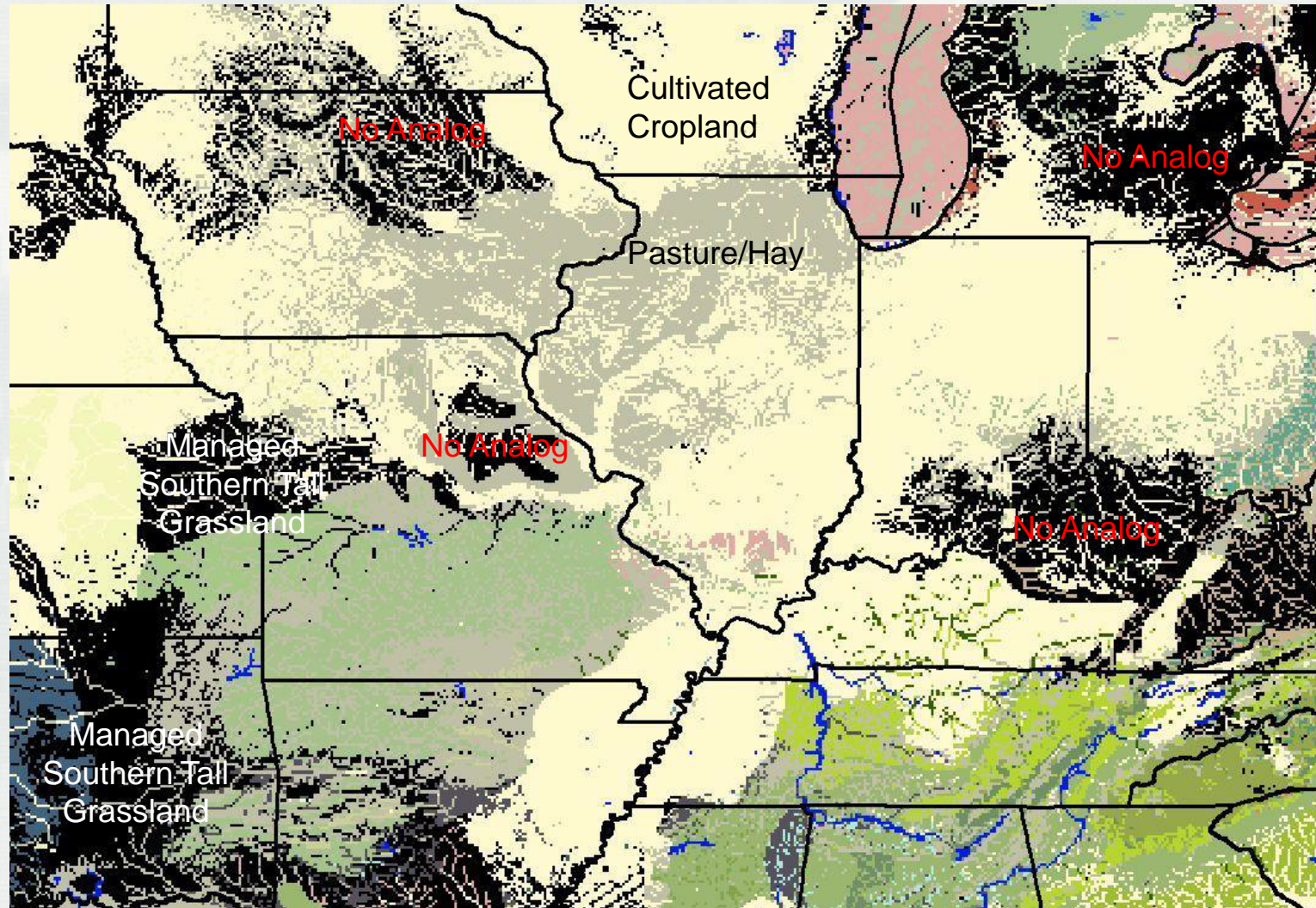
Illinois GAP – Current



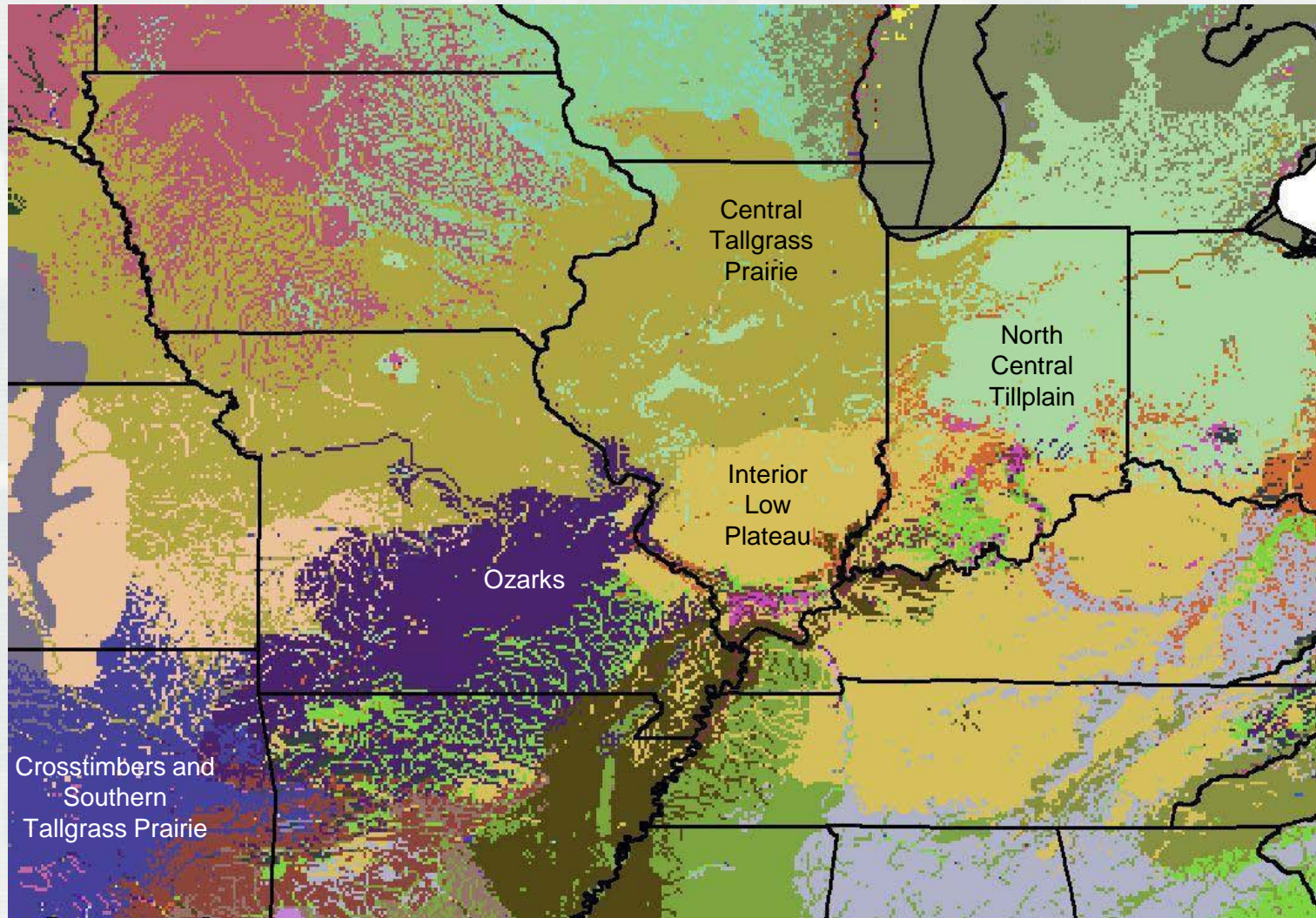
Illinois GAP – PCM A1 2055



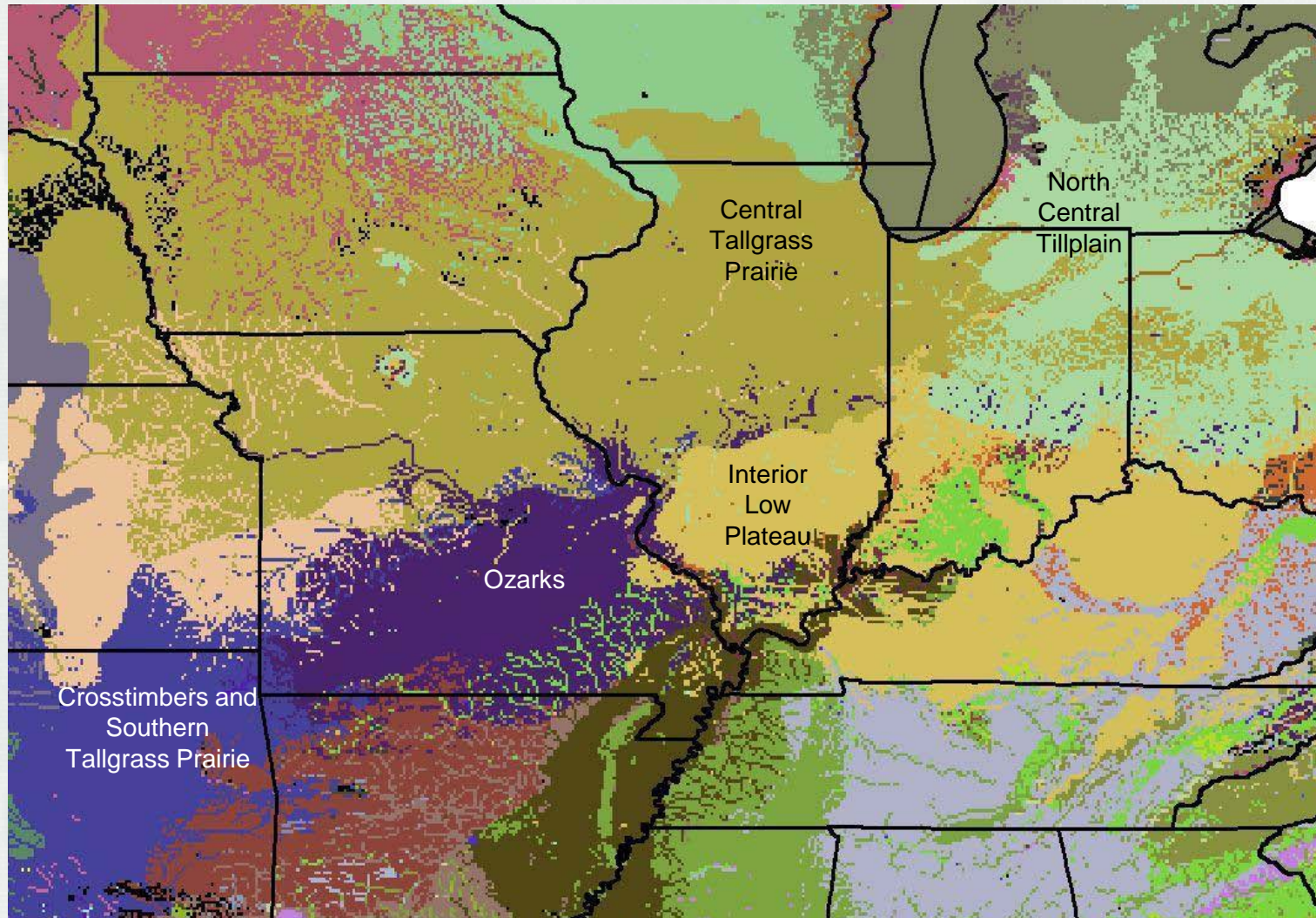
Illinois GAP – PCM A1 2085



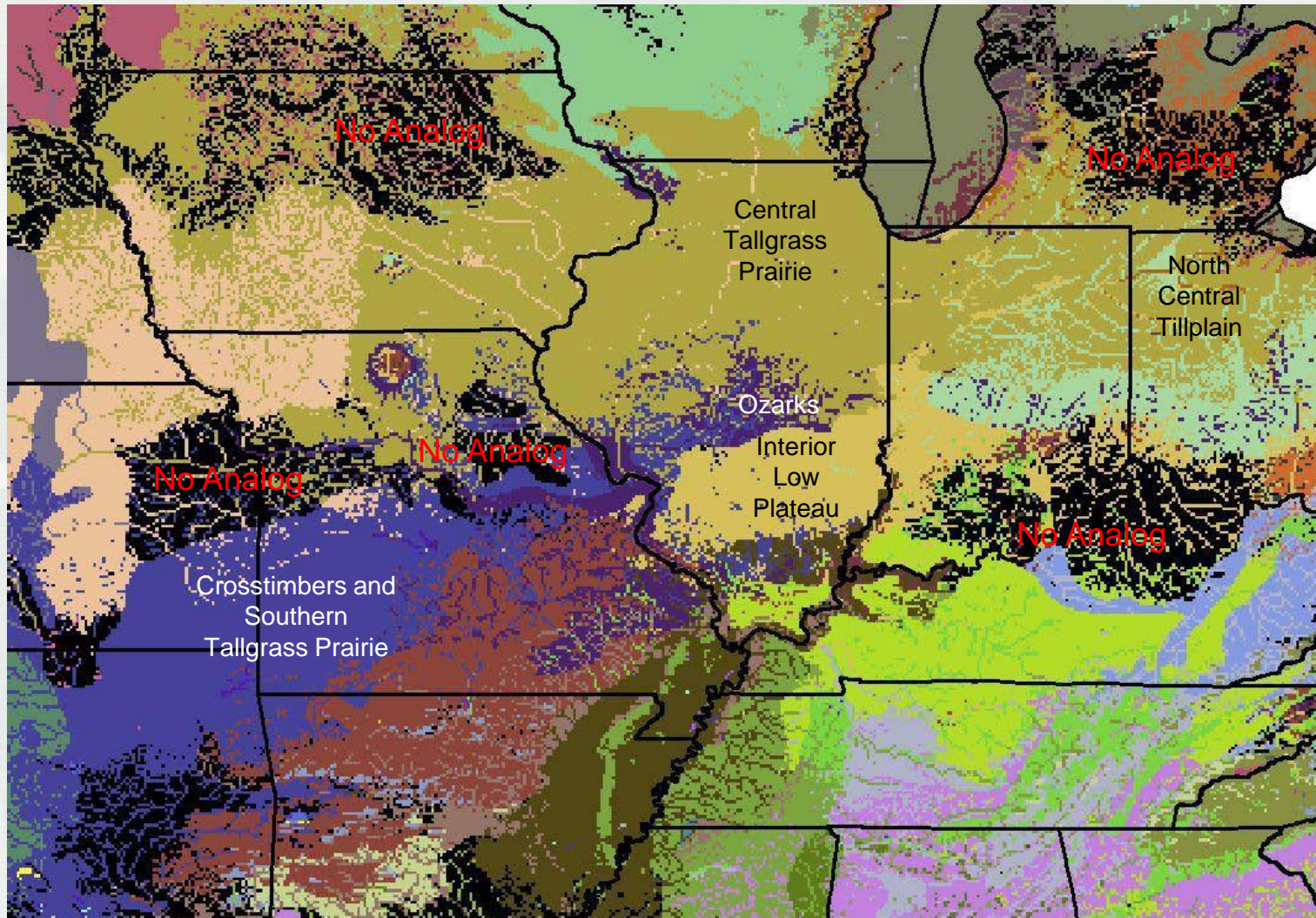
Illinois TNC – Current



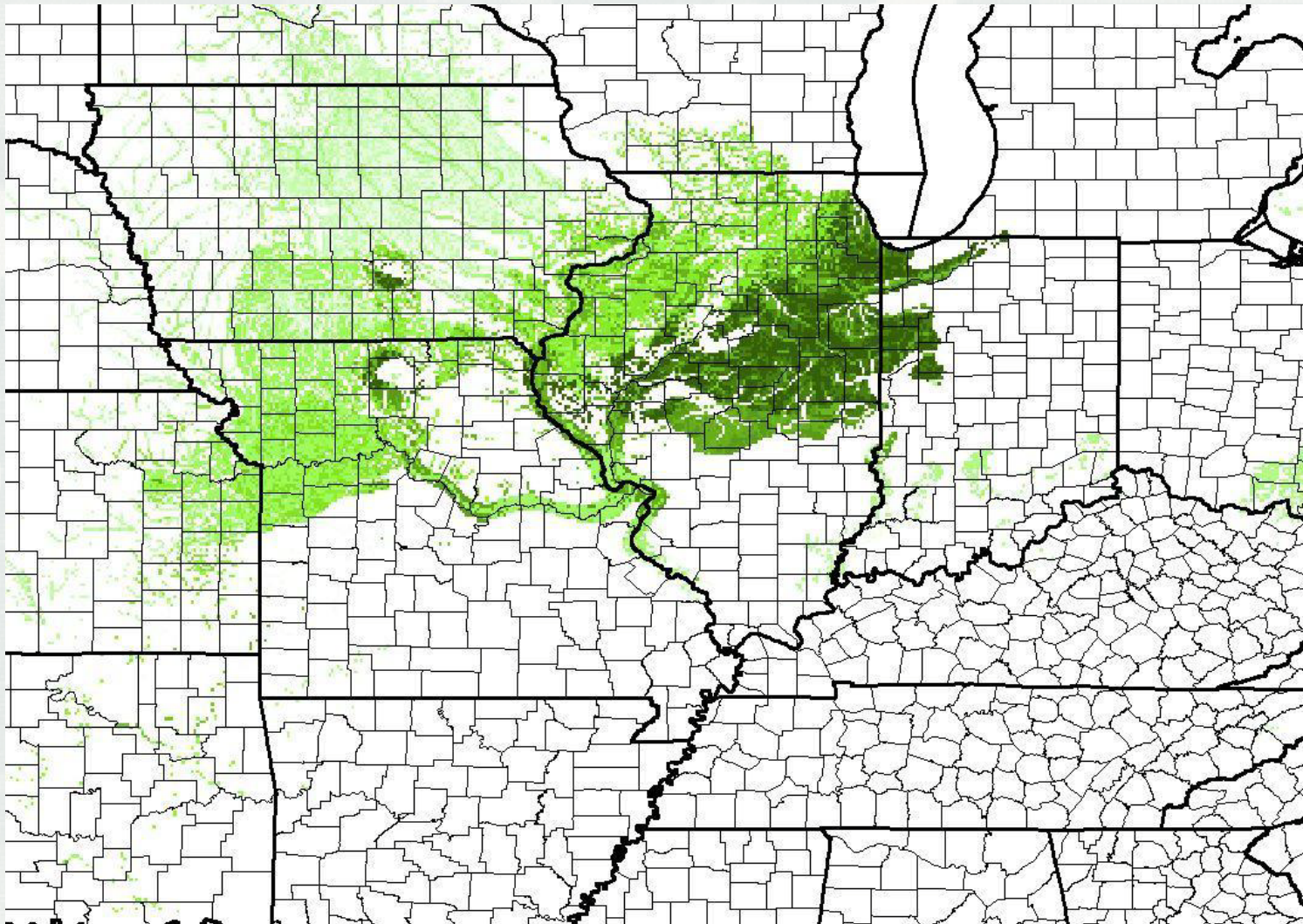
Illinois TNC – PCM A1 2055



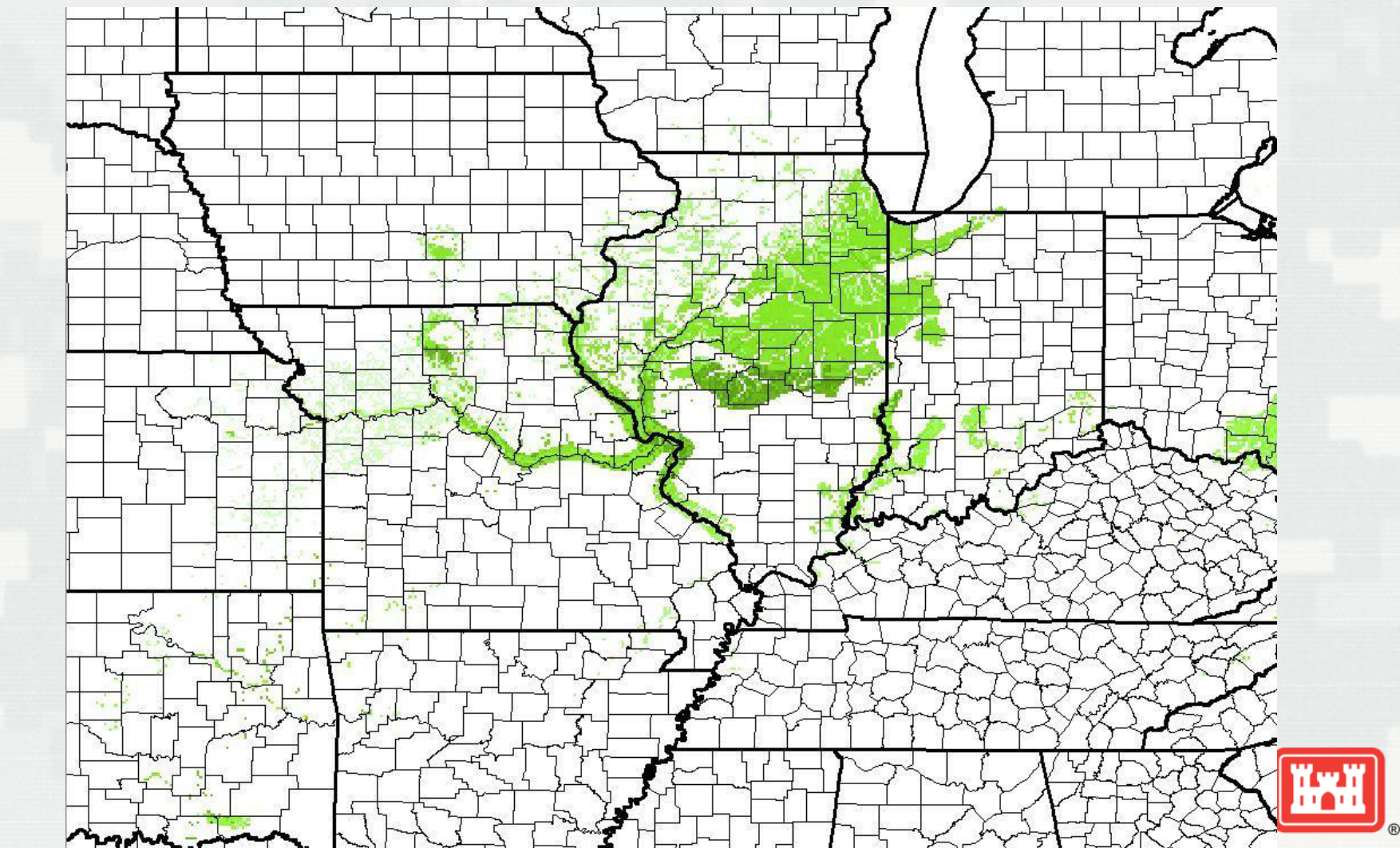
Illinois TNC – PCM A1 2085



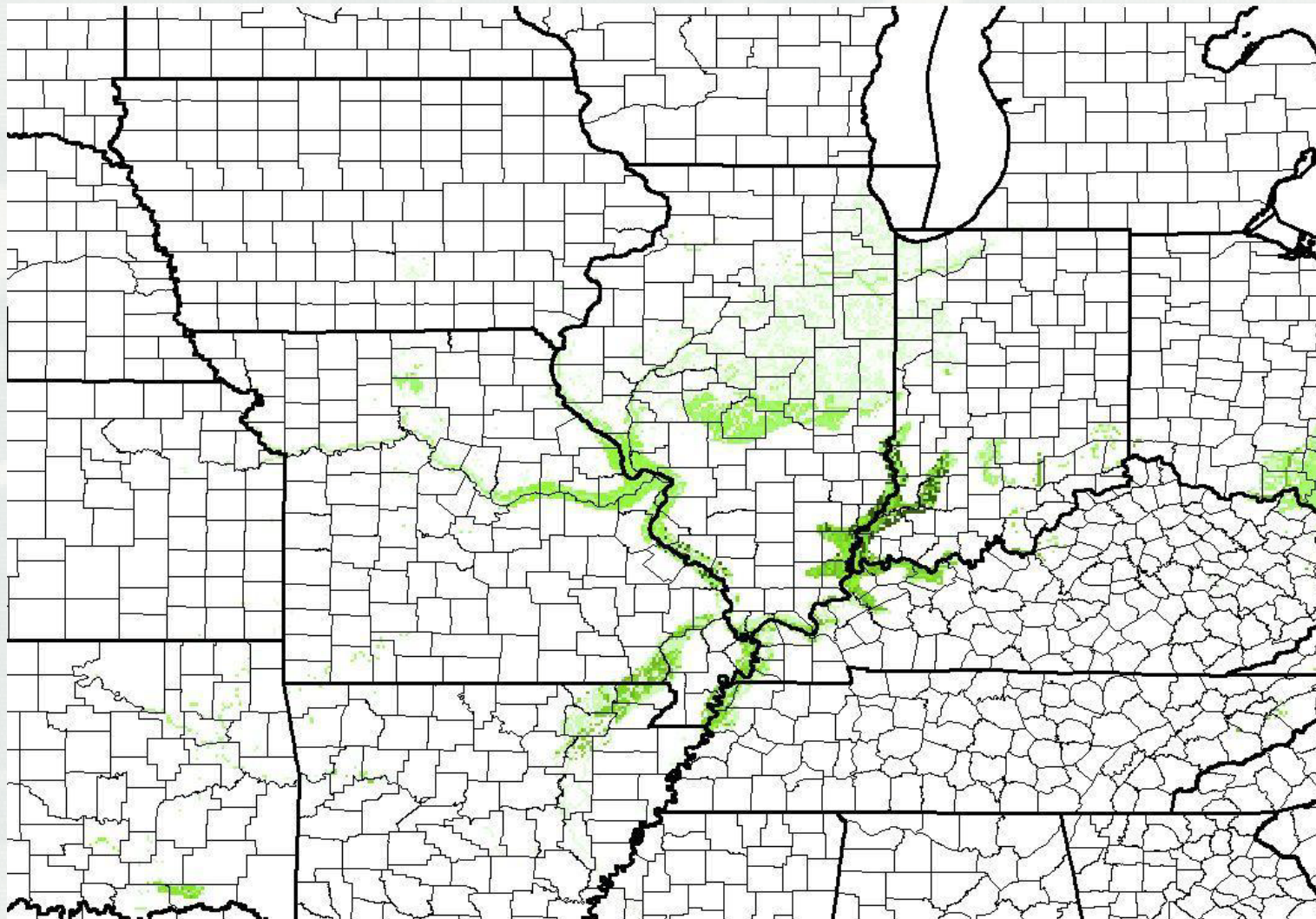
East-Cent III – Similar – Current



East-Cent III – HAD B1 2055



East-Cent III – HAD B1 2085



Results for Military Installations

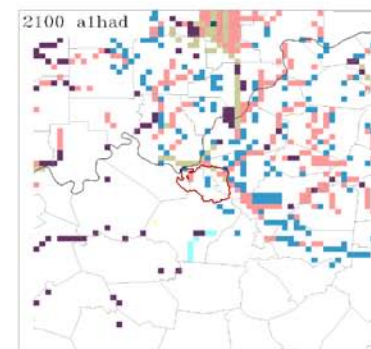
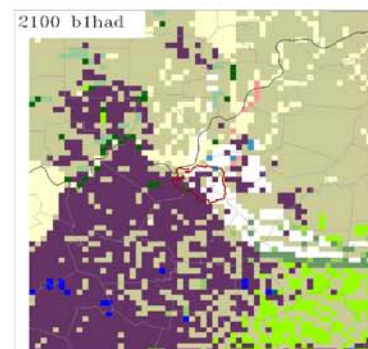
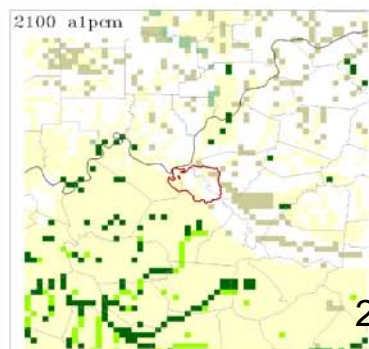
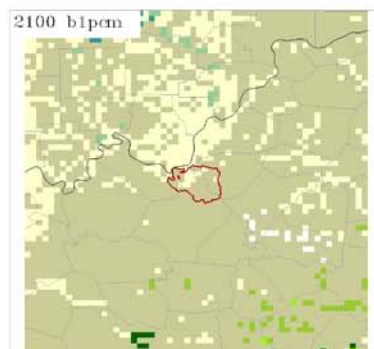
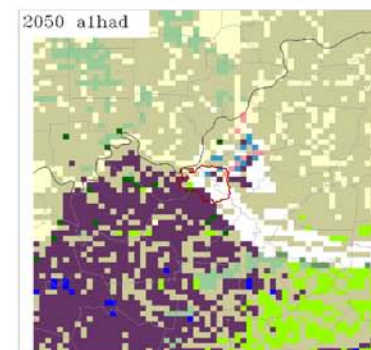
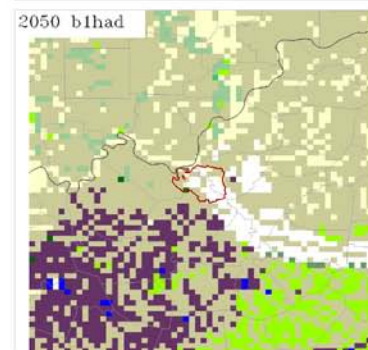
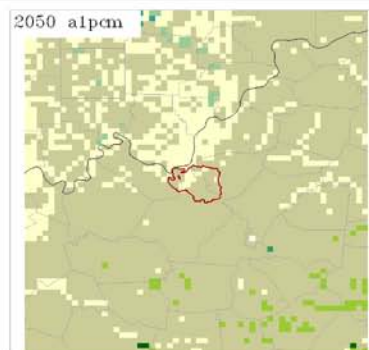
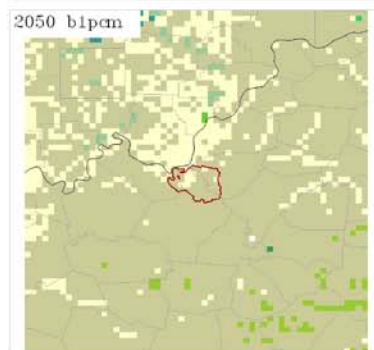
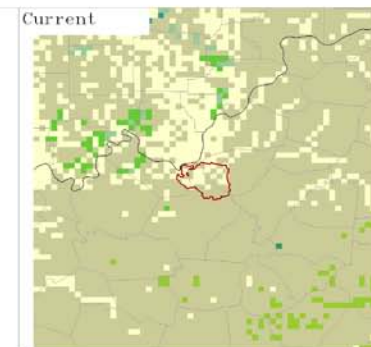
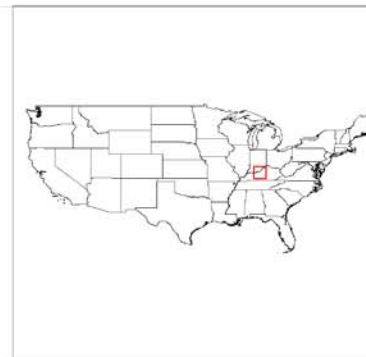
- All Navy, Marines, Air Force, and Army
- Two Models
 - ▶ Hadley and PCM
- Two Scenarios
 - ▶ A1 and B1
- Three times
 - ▶ 2000, 2050, and 2080



Sample GAP – Fort Knox

Fort Knox

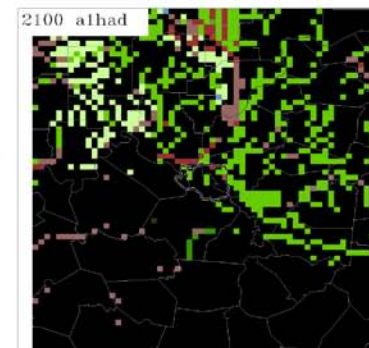
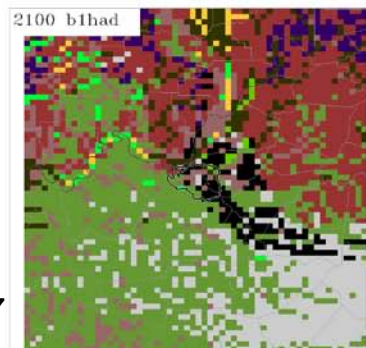
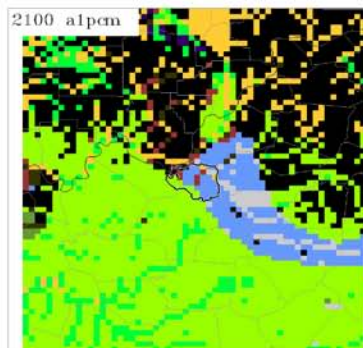
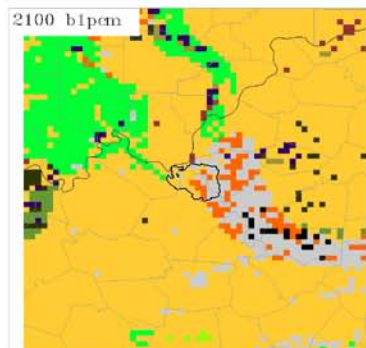
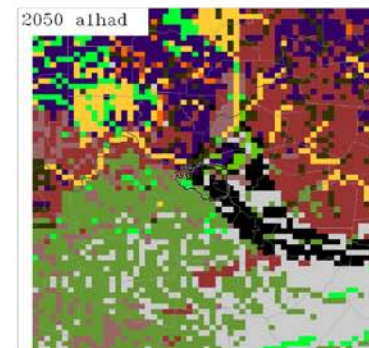
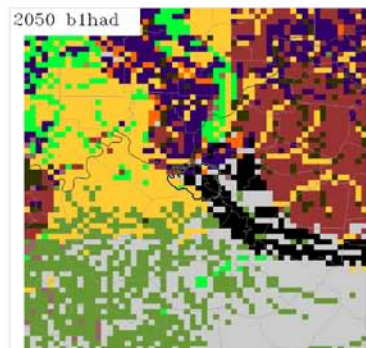
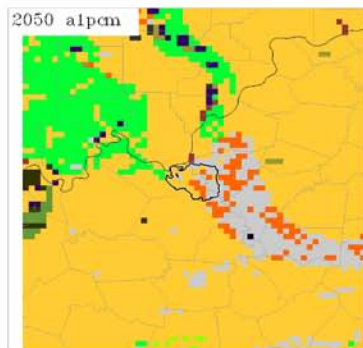
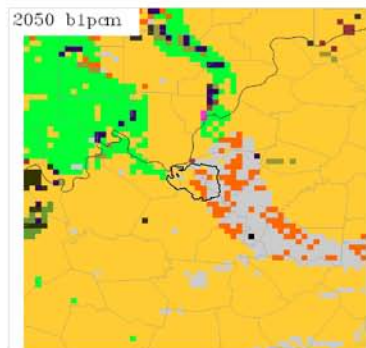
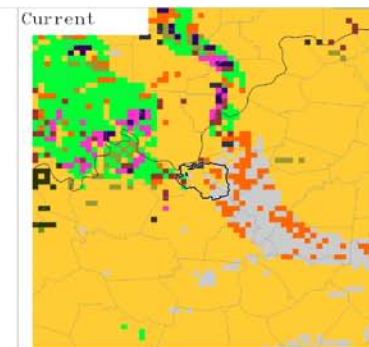
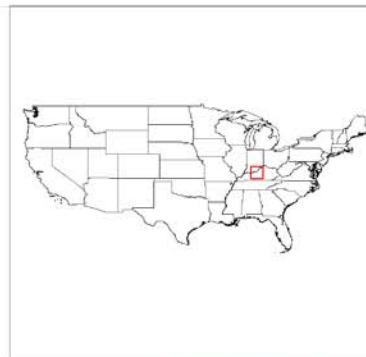
- 4115) Ozark-Ouachita Dry-Mesic Oak Forest
- 4116) Southern Interior Low Plateau Dry-Mesic Oak Forest
- 4126) Allegheny-Cumberland Dry Oak Forest and Woodland - Hardwood
- 4302) Southern Piedmont Dry Oak-(Pine) Forest - Hardwood Modifier
- 4328) Ozark-Ouachita Shortleaf Pine-Oak Forest and Woodland
- 4330) Central Appalachian Oak and Pine Forest
- 4332) West Gulf Coastal Plain Pine-Hardwood Forest
- 4334) Southern Ridge and Valley Dry Calcareous Forest
- 4401) Southern and Central Appalachian Cove Forest
- 4402) South-Central Interior Mesophytic Forest
- 4507) East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland - Loblolly Modifier
- 8202) Evergreen Plantations or Managed Pine (can include dense successional regrowth)
- 8203) Managed Tree Plantation
- 9804) East Gulf Coastal Plain Large River Floodplain Forest - Forest Modifier
- 9842) Atlantic Coastal Plain Small Brownwater River Floodplain Forest
- 9851) East Gulf Coastal Plain Small Stream and River Floodplain Forest
- 9908) West Gulf Coastal Plain Wet Longleaf Pine Savanna and Flatwoods



Sample TNC – Fort Knox

Fort Knox

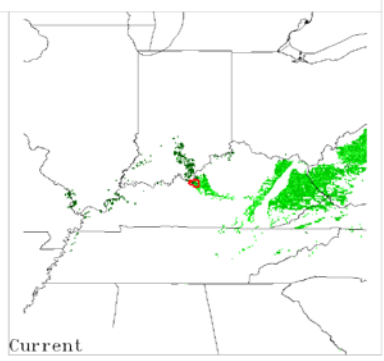
- 0) Different from any area in the world in 2000
- 98) 47% -Southern Acacia-Commiphora Bushlands And Thickets
- 185) 76% -Ouachita Mountains
- 186) 94% -Ozarks
- 187) 31% -Piedmont
- 189) 94% -Southern Blue Ridge
- 294) 64% -Araucaria Moist Forests
- 503) 81% -Mid-Atlantic Coastal Plain
- 705) 56% -Central Appalachian Forest
- 706) 56% -Chesapeake Bay Lowlands
- 707) 30% -Cumberlands And Southern Ridge And Valley
- 710) 38% -Interior Low Plateau
- 712) 61% -Mississippi River Alluvial Plain
- 715) 31% -Upper East Gulf Coastal Plain
- 716) 44% -Western Allegheny Plateau
- 727) 82% -South Atlantic Coastal Plain
- 729) 84% -Upper West Gulf Coastal Plain



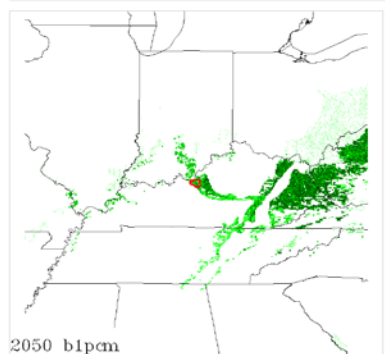
Sample Similar – Fort Knox

Fort Knox

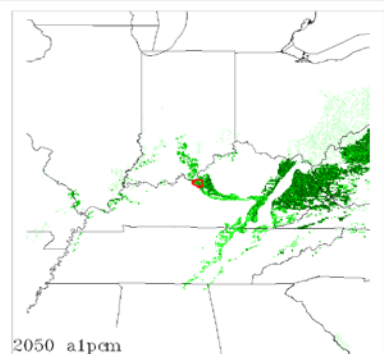
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"



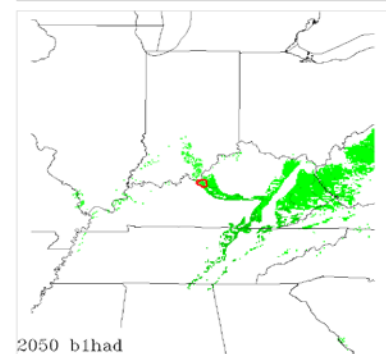
Current



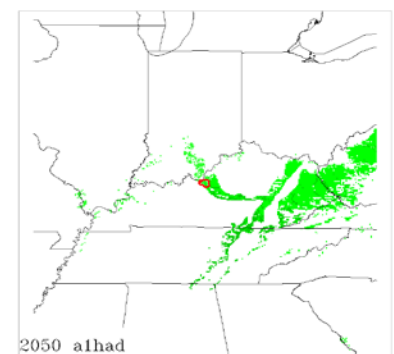
2050 b1pcm



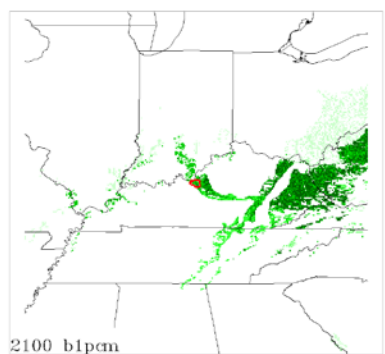
2050 a1pcm



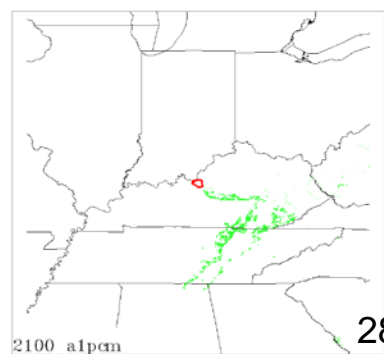
2050 b1had



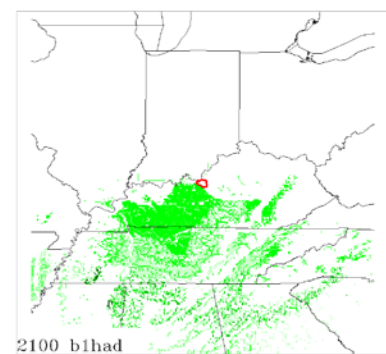
2050 a1had



2100 b1pcm



2100 a1pcm



2100 b1had



2100 a1had

Discussion

- We have a process for turning GCM/RCM forecasts into potential future ecosystem maps.
- We applied the process to the last round of forecasts
- Ready to apply to the next round
- Massive ecosystem shifts?



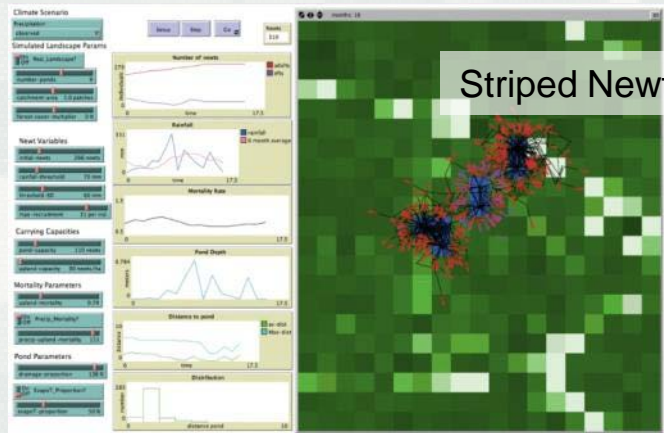
Next?

Two parts:

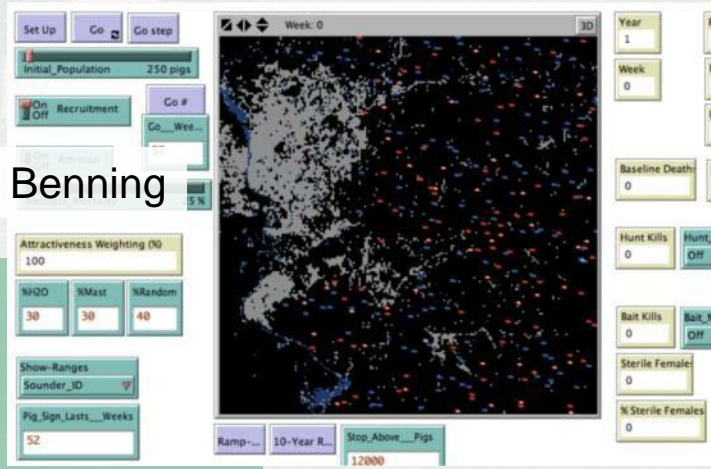
- Forecasted conditions currently support what ecosystems? ✓
- How and when will current ecosystems shift in response?
 - ▶ Resilience
 - ▶ Persistence
 - ▶ Seed distribution rates
 - ▶ ??



Some Ecological Sim Models

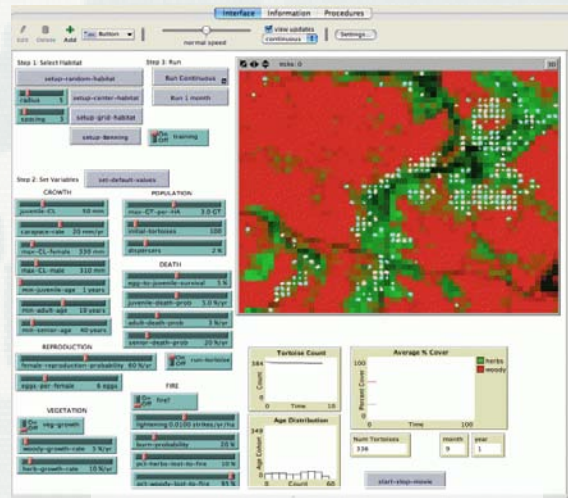


Striped Newt, Ft. Stewart

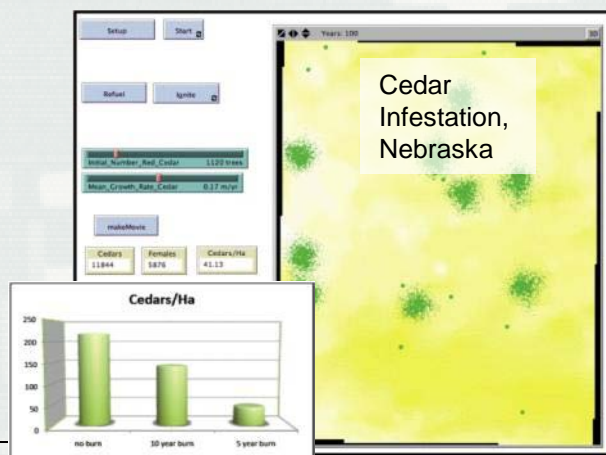


Feral Hogs, Fort Benning

- Quick
- Spatial
- Agent-based



Gopher Tortoise, Ft. Benning



Cedar Infestation, Nebraska



Fire Ants and Cave Crickets, Ft Hood



Questions??

- Sample Forest Service forecasts of movement of optimal tree habitat:
 - http://www.geobabble.org/~hnw/global/treeranges/climate_change2
- ERDC-CERL forecasts of ecosystem shifts around military installations:
 - ▶ <http://earth.cecer.army.mil>

